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OCT 82 J W CARR, M W BLADES, G M HIEFTJE N00014-76-C-0838
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The removal of the torch box from the matching network and its subsequent mounting on commercially available translation stages permits precise and accurate positioning of the plasma. This positioning capability, without the required movement of cumbersome pieces of equipment, facilitates fundamental studies and the routine use of the ICP as a source for analytical spectroscopy.

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A Separated Impedance Matcher/Load Coil Assembly for Convenient Spatial Translation of an ICP Torch

by

J. W. Carr, M. W. Blades, and G. M. Hieftje

Prepared for Publication

in

APPLIED SPECTROSCOPY

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Department of Chemistry
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8 October 1982

A

INTRODUCTION

Spatial studies of analyte emission in the inductively coupled plasma have revealed wide variance in the position of maximum signal.[1] Obviously, in routine chemical analysis best results are obtained when emission is viewed in this region. Moreover, in fundamental or developmental studies on the ICP it is often necessary to scan or observe atypical regions of the plasma discharge. Such scans or the selection of spatial observation regions can be accomplished by several alternative means.

In particular, spatial selection in the ICP is possible by a) raising or lowering the imaging optics or b) raising or lowering the plasma torch box and impedance matching network. The technique of moving the optics is useful over only small distances. If the distance to be moved is excessive, problems such as coma and astignatism associated with off-axis observations reduce the spatial resolution of the measurement. In addition, when optics are displaced, the observation beam must enter the monochromator at an angle and a portion of the entering light will not reach the photodetector. Of course, these problems can be corrected by translating the monochromator along with the imaging optics. However, this solution presents the problem of repeatedly positioning large objects such as a monochromator over the submillimeter distances necessary for the collection of spatially resolved data. Furthermore, when one is concerned with absorption or fluorescence measurements of species in the ICP, the excitation beam must be moved in conjunction with the observation beam. For example, in the case of laser-induced fluorescence the laser beam and focusing optics must all be raised or lowered along with and precisely the same distance as the imaging optics, monochromators and detector.

The second method of changing the observation region, that of raising or lowering the torch, reduces the problem to the movement of a single component. Here again, however, the problem recurs of moving a rather large piece of equipment reproducibly over small distances. To alleviate this problem it is possible to separate the torch box from the impedance matching network and translate only the ICP torch and surrounding radiofrequency radiation shield. Importantly, the size and weight of the enclosing radiation shield can be substantially reduced over the standard plasma box, enabling the use of accurate, small and relatively inexpensive micrometer-controlled translation stages for the positioning of the plasma. Commercially available stages also lend themselves to automation and computer control at a fairly low level of complexity and cost. A separated impedance matcher-torch assembly of this type has been built in our laboratory and is the subject of this report.

EXPERIMENTAL

A 5 kW Plasma-Therm inductively coupled plasma system (Plasma-Therm, Inc., Kresson, NJ, RF power supply model HFP 5000D, automatic power control model AMNPS-1 and impedance matching network model AMNS-5000E) was modified to separate the torch and load coil. The original torch housing, the load coil, load coil mounting blocks and plastic torch mount, were detached from the impedance matching network and installed in a new, lightweight radiation shield constructed from 1/4" aluminum plate and 1/32" copper sheet metal. The copper was used on three structurally unimportant faces of the new housing to reduce weight (cf. Figs. 1 and 2). The aluminum plate was used where the housing connected to the radiation shield,

where it connected to the impedance matching network and on the bottom where it supported the nebulizer and spray chamber. The load coils, load coil mounting blocks and plastic torch clamp were mounted inside the new radiation shield in the same orientation found in the original unit. An insulated teflon feed-through was employed to mount the "hot" side of the load coil, therby isolating it from the radiation shield. This insulator was identical to the original that remained on the impedance matcher housing. Radiofrequency power was conducted to the remote load coils through tinned braided-copper cables (3/4" x 1/8" x 11"). To prevent arcing and reduce hazard to the instrument operator, the conducting braids were covered with an insulating layer.

The isolated radiation-shield/torch assembly was mounted on three Newport Research Corporation (Fountain Valley, CA) micrometer-controlled translation stages (horizontal axis 1" movement, model 420-1, vertical axis 2" movement, model 440-2) permitting movement of one inch in either horizontal direction and two inches in the vertical direction. The scale drawing in Fig. 1 illustrates a view along the observation axis. In Fig. 1, the "S" configuration of the braided cables provides freedom of movement in three dimensions.

Figure 2 depicts the nebulizer and spray chamber mounted beneath the torch box. With these compoents placed outside the radiation shield, the overall dimensions of the housing and therefore its weight could be further reduced. A delrin insulating block (3" x 3" x 2") was placed between the torch box and the vertical translation stage to prevent the passage of large amounts of current through the translation stages during plasma ignition. In early trials, this high current resulted in bearing erosion in the stages, substantially reducing their positioning accuracy.

In the present arrangement the separated torch housing, translation stages and impedance matching network are mounted together on a large 1/2" thick aluminum sheet, which is set on optical riders and supported by optical rails.[2] The aluminum base was drilled and tapped on 2" centers, allowing the placement of ancillary equipment at any location around the plasma (cf. Fig. 3).

The isolated torch housing is translated manually in its present configuration. Conversion of the system from manual to computer or remote control would be rather simple and could be implemented by means of a motor drive, micrometers or various other commercially available positioning devices. Manufacturers' specifications of the present translation stages indicate that the torch can be reproducibly positioned within a few μm of a desired location. However, the limiting factor in useful positioning accuracy is found to be flicker within the plasma discharge itself, and allows no greater than a tenth of a millimeter reproducibility. For this reason, micrometer control stages are not essential in this application, but offer a convenient means of reproducibly establishing torch location relative to a reference point.

Testing and Evaluation. Ignition of the plasma was found to be straightforward using standard operating procedures, typical plasma, auxiliary and aerosol gas flow rates, RF power settings and impedance match settings. Moreover, under automatic impedance-matching operation, the presence of the braided cables produced no significant tuning changes.

In order to verify the similarity of the translatable plasma to an unmodified unit, horizontal spatial emission profiles of magnesium obtained at several heights above the load coils in the modified system were compared

with emission profiles of the same element from a standard ICP unit.[1] Both neutral atom (285.2 nm) and ion (280.3 nm and 279.5 nm) lines were investigated with no noticeable differences between the torch configurations being apparent (cf. Fig. 4). The plot of the two ion lines depict the characteristic dip in maximum emission intensity near the aerosol channel.

Radiation leakage from the exposed braided cable was checked as a possible radiation hazard. A radiation hazard meter (General Microwave Corporation, Farmingdale, NY, model 2) was used to detect the radiation density at various distances from the braided power cables. At a distance of 1.5 cm from the braided cables, radiofrequency power density was found to be less than 5 mW/cm^2. Beyond distances of 3 cm the RF power was not detectable on the most sensitive scale (2 mW/cm^2 full scale) of the available instrument. Under normal operating conditions the operator is approximately 1 m from the torch housing; even when engaged in manually translating the plasma, he ordinarily remains at least 25 cm from the power cables. Consequently it was judged that no significant radiation hazard exists in the new arrangement.

The removal of the torch box from the matching network and its subsequent mounting on commercially available translation stages permits precise and accurate positioning of the plasma. This positioning capability, without the required movement of cumbersome pieces of equipment, facilitates fundamental studies and the routine use of the ICP as a source for analytical spectroscopy

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REFERENCES

1. M. W. Blades and G. Horlick, Spectrochim. Acta 36B, 861 (1981).
2. J. P. Walters, in Contemporary Topics in Analytical and Clinical Chemistry, Vol. 3, D. M. Hercules, G. M. Hieftje, L. R. Snyder, and M. A. Evenson, Eds. (Plenum Press, New York, 1978) , p. 91.

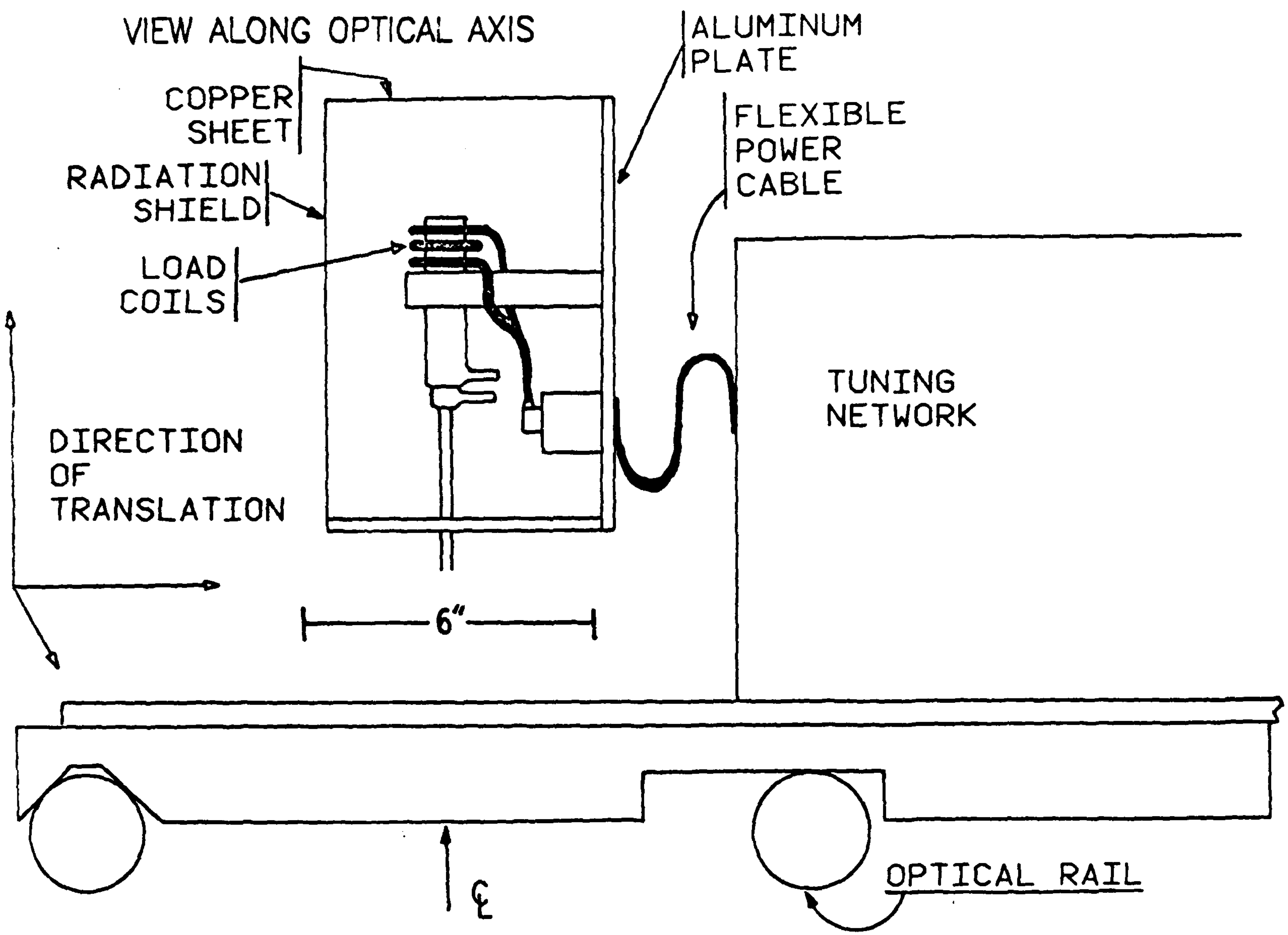
FIGURE CAPTIONS

Figure 1. View along observation axis of new translatable torch housing.

Figure 2. Front view of lightweight translatable torch housing.

Figure 3. Top view of translatable torch housing, impedance matching network and optical table.

Figure 4. Horizontal emission profiles of magnesium ion and atom lines obtained with the new translatable torch. Vertical location in plasma - 6.35 mm above load coil. Other spatial profiles similar to those in reference 1.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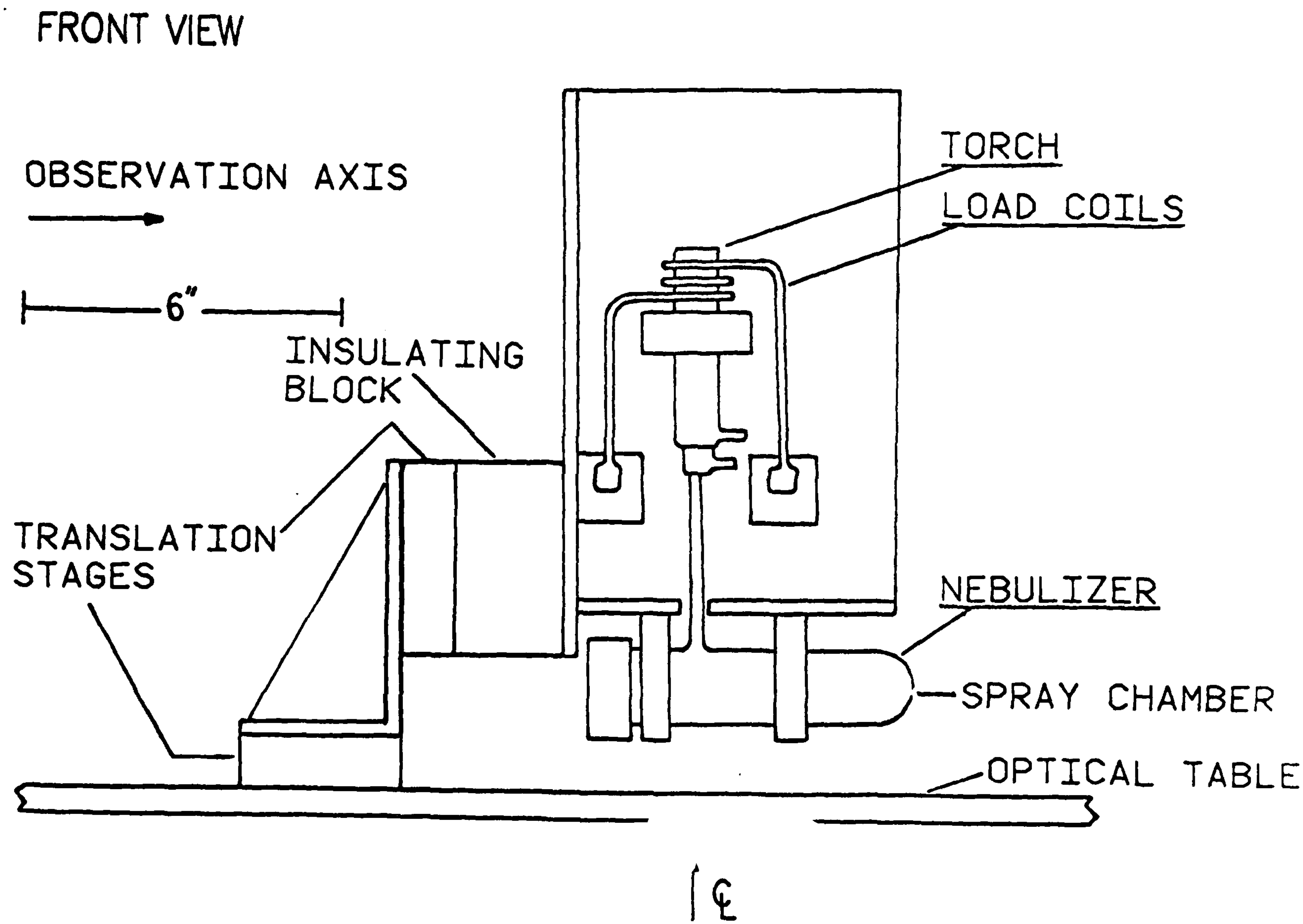
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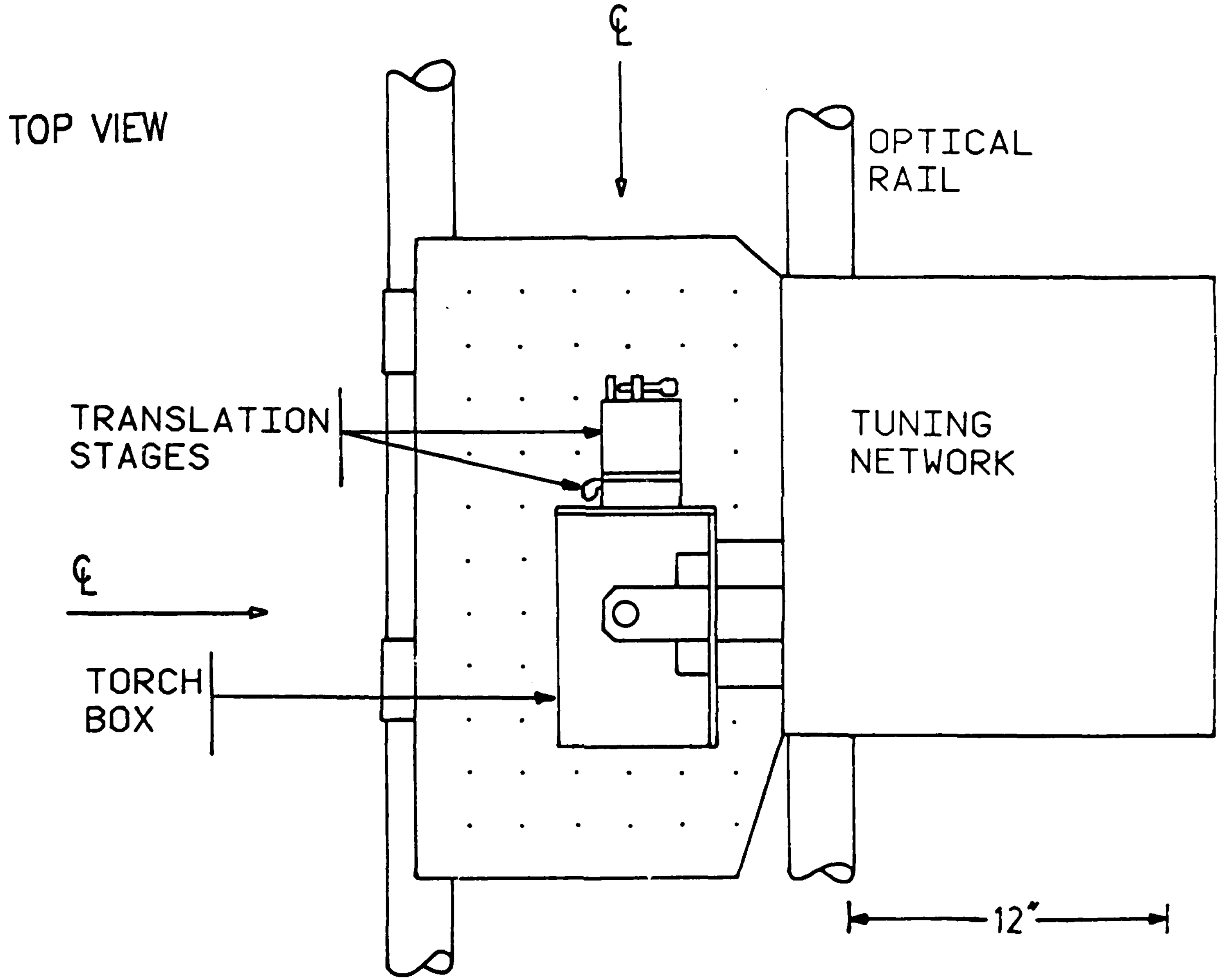
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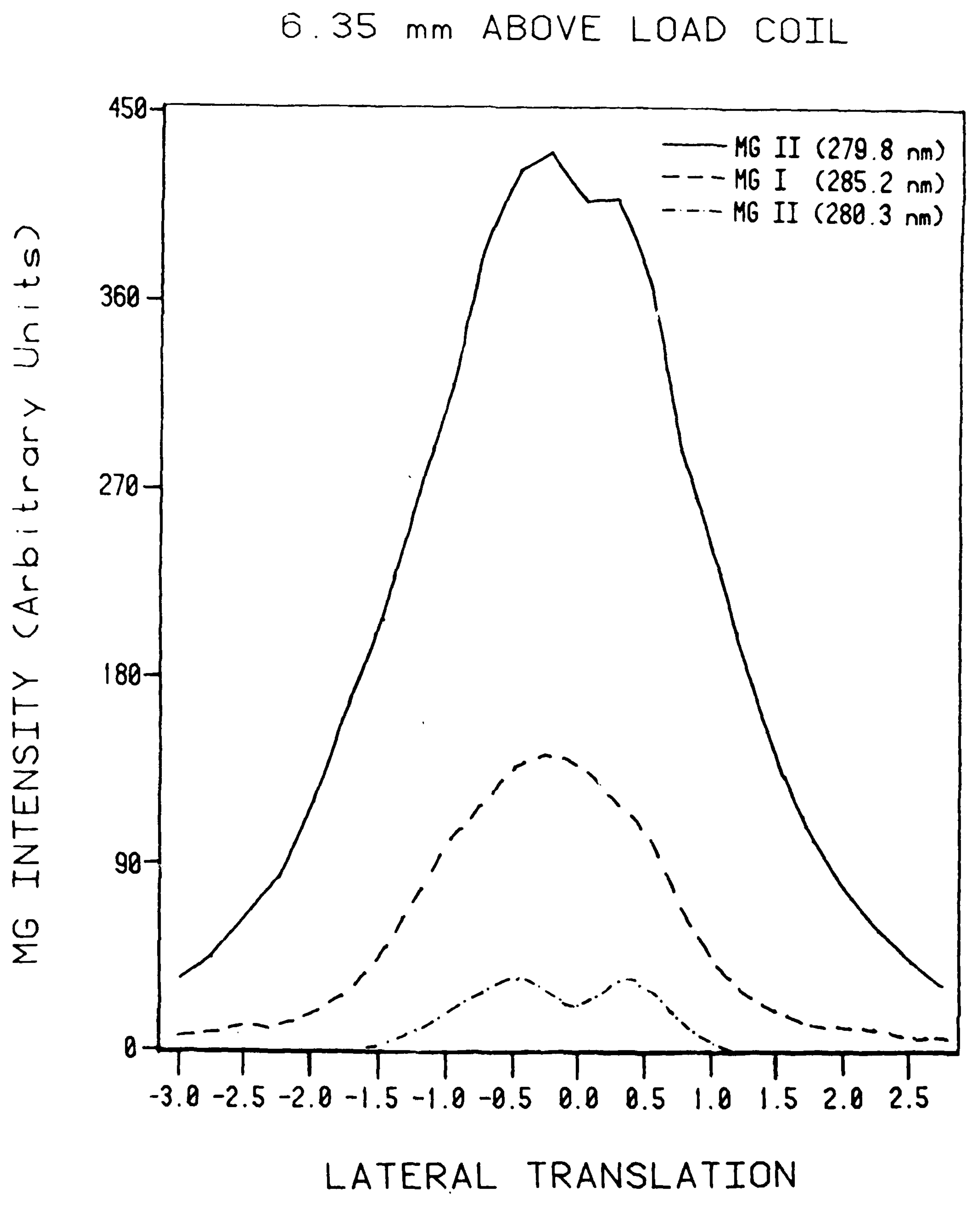

6.35 mm ABOVE LOAD COIL
MG II (279.8 nm)
MG I (285.2 nm)
MG II (280.3 nm)
MG INTENSITY (Arbitrary Units)
450
360
270
180
90
0
-3.0 -2.5 -2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0 2.5
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